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Regional Tissue Metabolism During Open or Endovascular Abdominal Aortic Aneurysm Surgery*

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Objective: *to investigate differences in regional tissue metabolism between open and endovascular aneurysm repair utilising a microdialysis technique.*
Materials: *eight patients receiving endovascular stent grafts (STENT) and six patients undergoing open aortic surgery (OPEN) for abdominal aortic aneurysms were studied prospectively but non-randomised.*
Method: *microdialysis catheters placed subcutaneously in the pectoral and calf region, respectively.*
Results: *microdialysate glucose levels increased in the OPEN group on the day of surgery. Microdialysate lactate levels increased transiently in the leg in the STENT group. In the OPEN group lactate increased in the leg after aortic cross-clamping. Glycerol decreased in the pectoral region in the STENT group after surgery, but remained elevated in the OPEN group.*
Conclusion: *we found indications that the metabolic impact of the two aortic procedures differ. This may be of clinical importance when selecting patients for either open aortic surgery or endovascular stentgrafting.*

Key Words: Endovascular surgery; Vascular surgery; Adipose tissue metabolism; Microdialysis.

Introduction

Previous studies comparing endovascular and open aortic surgery suggest differences in the inflammatory responses.[1–5] Systemic and local tissue metabolic effects of aortic surgery and aortic clamping have also been studied.[6–8]

It is now possible to monitor metabolic alterations over a longer time period in various tissues utilising a microdialysis technique.[9,10] The aim of our clinical study was to compare these changes during and after endovascular stent procedures and traditional open abdominal aortic surgery. We tested the hypothesis that aortic stent procedures would cause a lesser impact on regional tissue metabolism than an open aortic procedure.

Material and Methods

The study was approved by the Ethics Committee at the Medical Faculty, Lund University. Informed consent was obtained prior to the study procedure.

Fourteen patients (Table 1) with infrarenal abdominal aortic aneurysms were studied. The first group (STENT) included eight patients having an endovascular stentgraft procedure (three tubular, five aortobi-iliac). The second group (OPEN) included six patients undergoing traditional open surgery (four tubegrafts, two aortobi-iliac grafts). One patient in the OPEN-group was started as an endovascular stent grafting, but the procedure was converted to open surgery due to technical difficulties.

Procedure

The patients fasted overnight. The microdialysis catheters were placed early on the morning of surgery. Before admission to the OR a 2.5 % glucose infusion, 1 ml/kg/h, was started to standardise the glucose intake.

All patients had general anaesthesia induced with sodium pentothal, fentanyl and a muscle relaxant. Anaesthesia was continued with fentanyl, nitrous oxide/oxygen, a volatile anaesthetic and muscle relaxants as needed. Three patients in the OPEN-group had supplemental epidural anaesthesia. Standard surgical procedures were performed.

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Table 1. Patient characteristics.

	STENT ($n=8$)	OPEN ($n=6$)	Statistics
Sex: female/male	2/6	2/4	*
Age: years	69 (56–76)	67 (61–71)	NS
Weight: kg	79 (65–102)	82 (65–106)	NS
Height: cm	173 (161–189)	173 (161–181)	NS
Body Mass Index	26 (24–34)	27 (22–34)	NS
Ankle Blood Pressure Index	1.11 (0.9–1.43)	0.96 (0.4–1.15)	NS
Concomitant peripheral occlusive disease	1	1	*
Aneurysm diameter; cm	5.1 (3–7)	5.9 (5–7)	NS

Data are presented as mean and (range). NS = not significant.
* Not statistically tested.

Microdialysis

Microdialysis catheters, CMA 60, 30 mm membrane, molecular cut off at 20 kDa (CMA Microdialysis AB, Stockholm, Sweden) were placed using a steel cannula introducer. Before insertion the skin was locally anaesthetised with 1 ml of lidocaine 1%. Two microdialysis catheters were placed in the subcutaneous tissue, one at the middle part of the lateral aspect of the left calf, and one in the left pectoral region. The catheters were perfused with a physiological perfusion fluid (CMA standard perfusion fluid).

The microdialysate collection started after 1 h of stabilisation, and continued for 24 h. The microdialysates were analysed for glucose, lactate, and glycerol contents by enzymatic and colorimetric methods (CMA 600 Microdialysis Analyser).

Statistics

Analysis of variance and the Mann–Whitney non parametric test were applied to the microdialysis data. Unpaired two-tailed *t*-test was applied to demographic and perioperative data. Values are presented as mean $\pm$ standard deviation in the figures and mean and range in the tables. A p-value less than 0.05 was considered significant.

Results

Two patients in the STENT-group had transient ischaemia in the legs which was resolved at the end of the procedure. There was a significantly lower blood loss in the STENT-group (Table 2).

Glucose

In the OPEN group the glucose levels rose both in the pectoral region and the leg over time, and were significantly higher than in the STENT-group (Fig. 1).

Lactate

In the OPEN group lactate increased in the the leg and remained elevated for several hours after aortic declamping. In the STENT group there was a significant change in the lactate level with an increase in the leg limited to a few hours after the stent expansion (Fig. 2).

Glycerol

The glycerol level in the pectoral region rose in both groups before the aortic intervention. After stenting/clamping the glycerol level in the pectoral region remained higher in the OPEN group. The glycerol change in the leg was less pronounced in both groups (Fig. 3).

Discussion

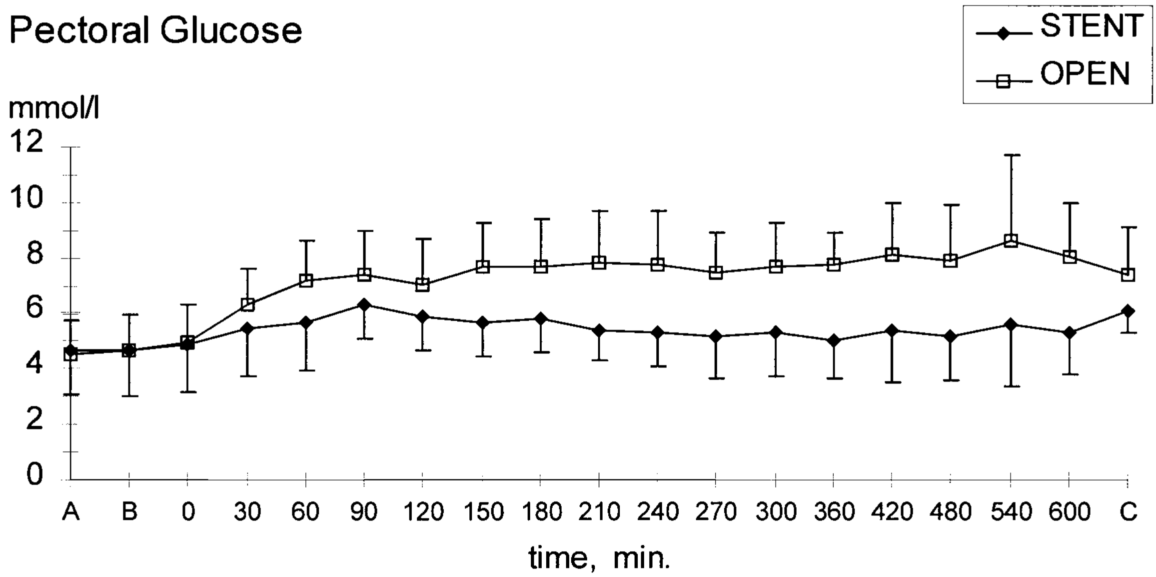
There were more pronounced changes in subcutaneous extracellular metabolites in the pectoral region and the leg in patients undergoing open abdominal aortic surgery compared to patients undergoing an endovascular aneurysmal repair.

The microdialysate glucose levels increased after open surgery. This might reflect a greater surgical trauma, leading to insulin resistance.[11–14]

Table 2. Perioperative characteristics.

	STENT ($n=8$)	OPEN ($n=6$)	Statistics
Aorta occlusion time (min)	—	72 (54–98)	*
Length of surgery (min)	158 (85–307)	191 (125–365)	NS
Infusion of inotropic drugs	2	6	*
Blood loss (ml)	319 (0–1000)	2033 (1000–3100)	$p<0.001$

Data are presented as mean and (range). NS = not significant.
* Not statistically tested.



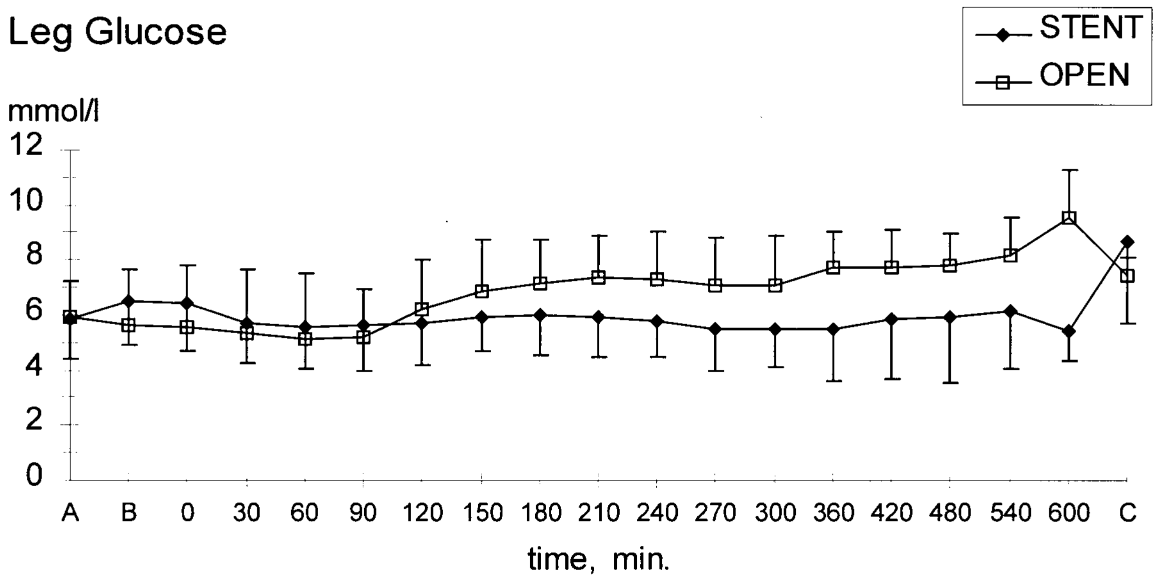


Fig. 1. Microdialysate glucose. (A) Before surgery; (B) during initial surgery; (C) next morning. The zero level refers in the STENT group to balloon occlusion of the aorta, and in the OPEN group to aortic clamping. Mean ± SD. Pectoral glucose: $p<0.001$ between groups. Leg glucose: $p<0.001$ between groups.

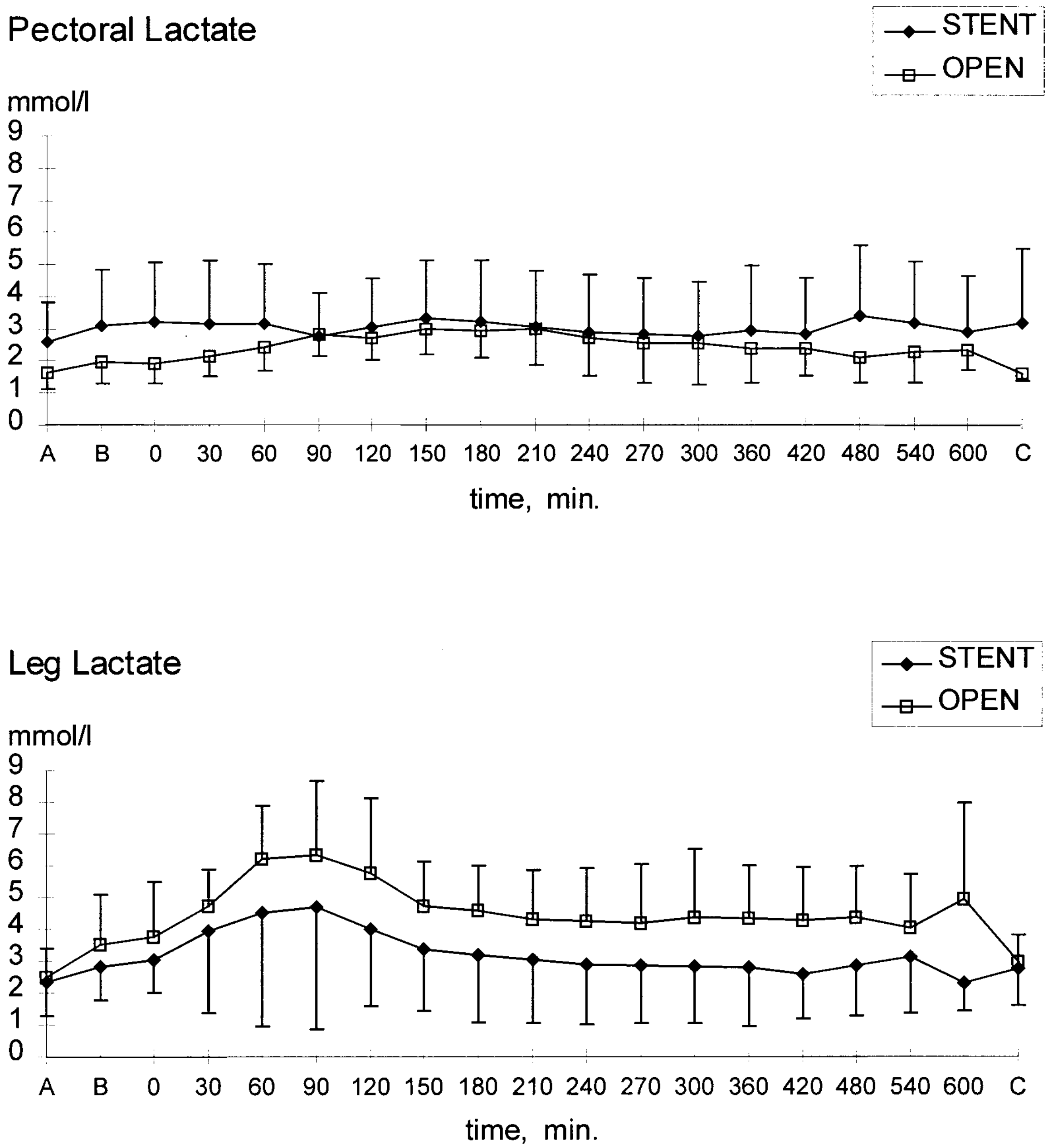


Fig. 2. Microdialysate lactate. (A) Before surgery; (B) during initial surgery; (C) next morning. The zero level refers in the STENT group to balloon occlusion of the aorta, and in the OPEN group to aortic clamping. Mean $\pm$SD. Pectoral lactate: NS between groups. Leg lactate: p<0.001 between groups.

During the stent procedure the lactate level was stable in the pectoral region while the transient increase in the leg was most likely due to the two patients with ischaemic episodes during the procedure. The more pronounced changes in subcutaneous lactate in the leg during open aortic procedures probably reflect effects of ischaemia and reperfusion.

Adipose tissue lactate increases during a glucose load.[15,16] However, we standardised the glucose intake at a low and continuous infusion to avoid inadvertent glucose peaks.

The changes in glycerol levels also differed between the groups. There was less lipolysis during STENT procedures, probably as a consequence of a lesser adrenergic response. Surgery induces a sympatho–adrenal response[17–22] and the degree depends on the extent of surgery.[19] For patients receiving endovascular stentgrafts the glycerol level in the pectoral region

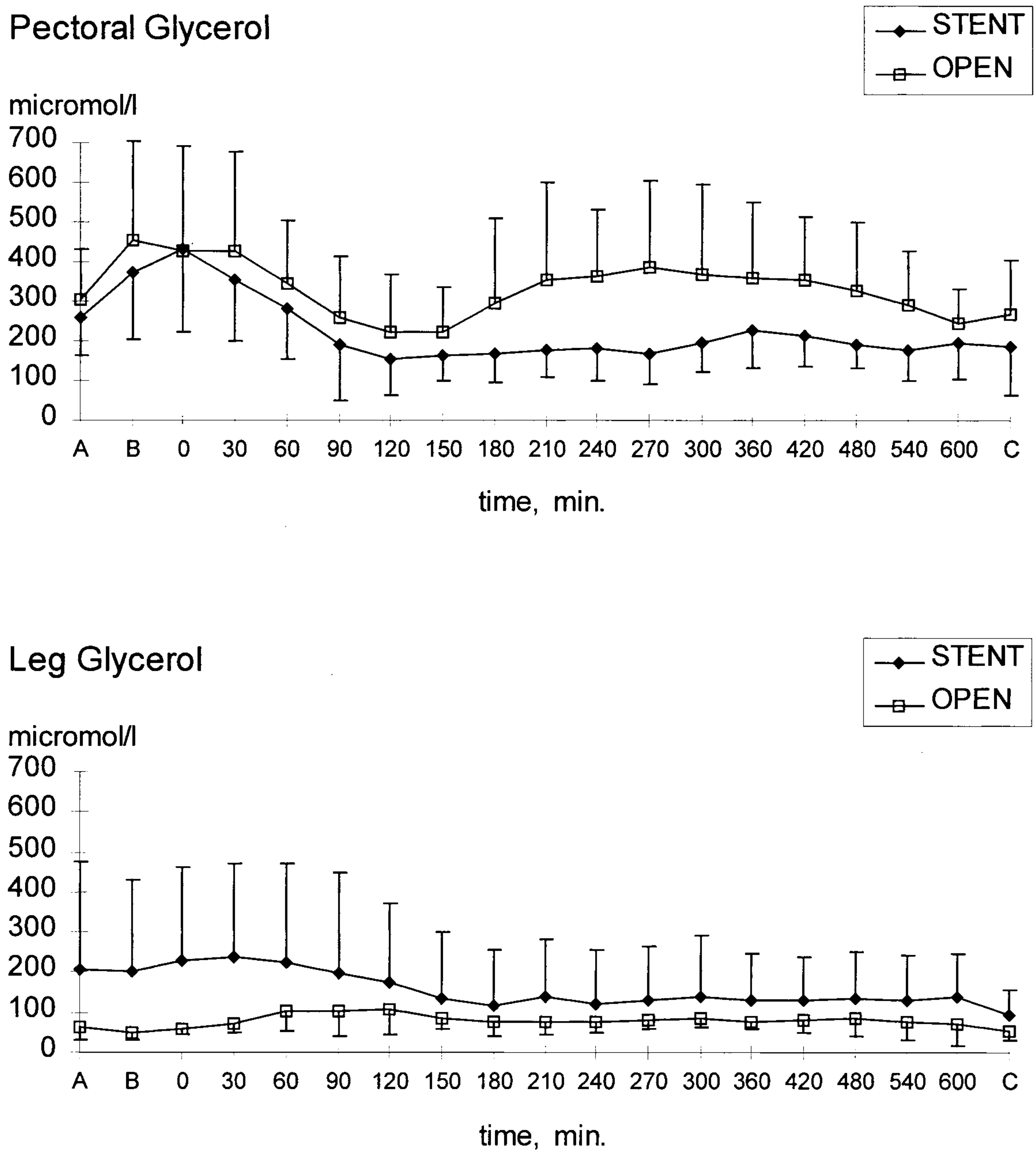


Fig. 3. (A) Before surgery; (B) during initial surgery; (C) next morning. The zero level refers in the STENT group to balloon occlusion of the aorta, and in the OPEN group to aortic clamping. Mean $\pm$SD. Pectoral glycerol: $p<0.001$ between groups. Leg glycerol: $p<0.001$ between groups.

actually decreased during the study period, while in the patients with open aortic surgery pectoral glycerol remained elevated. Catecholamine levels demonstrate a maximal increase immediately after surgery,[20] and the activation of stress-related factors during surgery seems to be less intense and of shorter duration with less invasive surgery.[19]

During open aortic surgery the patients had transient hypotensive episodes requiring inotropic support with dopamine, as judged by the anaesthetist. Two patients also had dopamine infusion in the immediate post-operative period. Only two patients in the STENT-group needed dopamine during surgery. This could further add to the metabolic differences between the two groups as dopamine has an impact on lipolytic activity and blood glucose levels.[23–25]

Periods of hypoperfusion may change the supply or outflow of metabolites, which means that microdialysate levels could change even without changes in metabolism.[26]

Patients were selected for different interventions depending on the aortic neck, its length and width, and the iliac artery tortuosity. Thus, the more complicated cases were treated with an open procedure, while the less complicated cases had an endovascular repair. Furthermore, three of six patients undergoing open surgery also had epidural analgesia, which may have influenced the metabolic response.

All patients in the STENT group had a blood loss less than 1000 ml, whereas all in the OPEN group had a blood loss over 1000 ml. This finding may also have had an impact on perioperative metabolism.

Thus, the differences in microdialysate metabolites during endovascular versus open surgery might be explained by several factors. Differences in surgical trauma, neuroendocrine response, haemorrhage, regional ischaemia, perioperative circulatory instability necessitating sympathomimetic drugs, hypoperfusion changing the levels of metabolites and the different perioperative management of the patients as endovascular approach and open surgery are quite different techniques for the same entity of patients. The pathophysiology of each technique has its own risks and different perioperative circumstances.

The present study included a limited number of patients and had some inhomogeneity between the groups. We are not able to point out which of the above discussed factors are of most importance for the suspected metabolic difference. However, the intention was merely to demonstrate a metabolic difference between the two surgical techniques.

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